



4910-06-P

## **DEPARTMENT OF TRANSPORTATION**

### **Federal Railroad Administration**

#### **Safety Advisory 2013-02**

#### **Low-Speed, Wheel-Climb Derailments of Passenger Equipment with “Stiff” Suspension Systems**

**AGENCY:** Federal Railroad Administration (FRA), Department of Transportation (DOT).

**ACTION:** Notice of Safety Advisory.

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**SUMMARY:** FRA is issuing Safety Advisory 2013-02 to alert railroads and other industry members about low-speed, wheel-climb derailments of certain passenger equipment designs having “stiff” suspension systems. These derailments have occurred when such equipment was negotiating track with a high degree of curvature and crosslevel variations (commonly referred to as “track warp”) that were still within the limits set forth in FRA’s Track Safety Standards. The findings from the derailment investigations conducted by FRA and the respective railroads highlight the need to ensure that passenger equipment suspension systems are suitable for more-demanding track conditions found in low-speed operating environments. To avoid similar low-speed, wheel-climb derailments, this notice recommends that railroads and other industry members evaluate the trackworthiness of certain passenger equipment to determine whether the suspension systems meet truck-equalization industry standards, prevent wheel climb, and control static wheel-load distribution under the conditions and within the limits described in the notice; and take appropriate action to address the derailment

tendency, if any, of the evaluated equipment. In order to minimize the risk of suspension spring failure, this notice also recommends that railroads and other industry members assessing the fatigue life of suspension springs and their corresponding maintenance intervals use a fatigue-evaluation load equal to the equipment's full-capacity loading conditions.

**FOR FURTHER INFORMATION CONTACT:** Michelle Muhlanger, Deputy Regional Administrator, Region 1, Office of Railroad Safety, FRA, 55 Broadway Street, Cambridge, MA 02142, telephone (617) 494-2630; Gary Fairbanks, Staff Director, Motive Power and Equipment Division, Office of Railroad Safety, FRA, 1200 New Jersey Avenue, SE., Washington, DC 20590, telephone (202) 493-6322; or Anna Nassif Winkle, Trial Attorney, Office of Chief Counsel, FRA, 1200 New Jersey Avenue, SE., Washington, DC 20590, telephone (202) 493-6166.

## **SUPPLEMENTARY INFORMATION:**

### **Background**

In response to increased performance objectives, such as higher operating speeds and increased passenger capacity, passenger equipment suspension systems are becoming stiffer<sup>1</sup> and more sophisticated, and may be approaching design limits. In many cases, engineering tradeoffs are made to meet performance objectives and satisfy specific system constraints (e.g., clearances for existing tunnels or other infrastructure). An example is equipment using non-linear vertical springs, which provide variable stiffness as the vehicle load increases from AW0 (i.e., empty vehicle ready to run) to AW3 (i.e., vehicle with full-seated and full-standee load). Such tradeoffs have resulted in certain

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<sup>1</sup> Suspension systems that allow lower suspension deflection for the same load (e.g., due to the use of less flexible springs).

newer designs of equipment being operated over more-demanding track geometry conditions with lower margins of safety, from a derailment perspective, than older equipment designs. The static weight distribution and marginal wheel-load equalization that are characteristic of such suspension system designs can lead to wheel unloading. This is of particular concern because FRA has determined that the combination of high, lateral curving forces and wheel unloading is a major contributing factor to low-speed,<sup>2</sup> wheel-climb derailment tendency. Similar wheel-climb derailments are not as likely to occur at higher speeds on higher classes of track because track curvature is generally less sharp and the safety limits on track-warp variations on such track are more stringent. See Title 49 Code of Federal Regulations (CFR) 213.63 and 213.331.

Although the derailments prompting issuance of this safety advisory all occurred on Class 1 track at speeds of 15 mph or less, and did not result in any injuries, the consequences could have been much worse. For example, one of the derailments resulted in the derailed train fouling the adjacent track on which a National Railroad Passenger Corporation (Amtrak) Acela Express train was traveling. Had the circumstances been different, a significant collision could have occurred. Thus, the recommendations in this notice are important not only in preventing low-speed, wheel-climb derailments themselves but in preventing what may be more serious consequences of such derailments.

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<sup>2</sup> Fifteen mph or less. The maximum allowable operating speed for passenger trains on Class 1 track, as defined under 49 CFR 213.9, is 15 mph. All references in this notice to a section or other provision of a regulation are to a section, part, or other provision in 49 CFR.

Although Federal regulations require suspension systems on Tier II<sup>3</sup> passenger equipment to reasonably prevent wheel climb and wheel unloading under all loading conditions and at all track speeds (see § 238.427), there is no equivalent requirement for Tier I passenger equipment (see § 238.227). Further, while the March 13, 2013, final rule on vehicle/track interaction (VTI) safety standards will promote the safe interaction of all rail vehicles with the track over which they operate under a variety of conditions, the rule focuses on high-speed and high cant deficiency operations, and does not address—in particular—the prevention of the type of low-speed, wheel-climb derailment that is the focus of this notice.

During the development of the VTI rule and as a result of working with a number of railroads to investigate several low-speed, wheel-climb derailments at that time, FRA recognized the need to address such derailments more comprehensively. Specifically, FRA was concerned that there needed to be greater compatibility between certain designs of passenger equipment (i.e., those having “stiff” suspension systems) and the lower track classes over which they operated, as such equipment was experiencing derailments while negotiating track with a high degree of curvature and with track warps that were still within the limits set forth in FRA’s Track Safety Standards. The Railroad Safety Advisory Committee (RSAC) task force that was assigned to assist FRA in developing the VTI rule was initially tasked to consider addressing the issue in that rulemaking. However, the task force, with the concurrence of the full RSAC, recommended that the issue be addressed by an industry standard on truck equalization, rather than in the VTI rule. To that end, the American Public Transportation Association (APTA) issued a

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<sup>3</sup> Tier II passenger equipment operates at speeds exceeding 125 mph but not exceeding 150 mph, whereas Tier I passenger equipment operates at speeds not exceeding 125 mph. See § 238.5.

standard on truck equalization.<sup>4</sup> However, the APTA standard applies to passenger equipment suspension systems loaded in the AW0 condition only, as wheel load equalization was traditionally seen as an issue principally affecting empty cars. Although APTA members recently voted to re-open the standard to incorporate further lessons learned from recent derailment investigations, FRA recognizes that it will take some time to do so. This notice of safety advisory is intended to more fully address the issue in the meantime.

#### Discussion of Specific Recommendations

The first recommendation is that railroads and other industry members conduct a trackworthiness evaluation of certain passenger equipment to determine whether suspension systems meet truck-equalization industry standards, prevent wheel climb, and control static wheel-load distribution under certain conditions and within certain limits. Because the manufacturing process inherently results in small variances in some of the vehicle's components, vehicle designs necessarily include a nominal value for certain components, as well as tolerances for those components. The designs also specify tolerances for maintenance limits to account for in-service wear and degradation of components. Thus, a trackworthiness evaluation of a vehicle type's performance should also take into account the full range of component tolerances (e.g., spring heights) and maintenance limits (e.g., wheel wear). Railroads and industry members should be aware that vehicles may or may not exhibit derailment tendencies over the range of new vehicle component tolerances. Similarly, vehicles with in-service wear that are still operating within all maintenance tolerances may or may not exhibit derailment tendencies.

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<sup>4</sup> See APTA SS-M-014-06, Standard for Wheel Load Equalization of Passenger Railroad Rolling Stock (2007).

Therefore, it is important to consider all combinations of component and maintenance tolerances in evaluating trackworthiness.

Although conducting such an evaluation at the design stage for new equipment is both desirable and feasible from a practical standpoint, FRA recognizes that it would be quite burdensome to conduct such an evaluation for all existing equipment. Therefore, FRA has focused the recommendations regarding existing equipment in this notice to situations that are easier to address or where the equipment is at greatest risk for experiencing similar derailments. Consequently, FRA is limiting the formal recommendations in this notice to existing equipment that (1) is undergoing a redesign of its suspension system that will likely affect the low-speed trackworthiness performance of the vehicle; (2) is being placed in service over a new route that the railroad knows to have more demanding track geometry conditions; or (3) has experienced one or more low-speed, wheel-climb derailments that may have involved a combination of wheel unloading and track warp of 3 inches or less as a contributing factor.

In addition, if the results of a trackworthiness evaluation indicate that the equipment's performance does not meet one or more of the conditions described, FRA is recommending different levels of action depending on whether the equipment is new (or redesigned) or existing. For new equipment or equipment undergoing a redesign of its suspension system that will likely affect the low-speed trackworthiness performance of the vehicle, FRA recommends that the suspension system be redesigned to perform according to the conditions described. For existing equipment, FRA is recommending that appropriate action be taken to mitigate the derailment tendency. This would include redesigning the equipment or taking other appropriate action, such as ensuring that the

track over which the equipment is operating is maintained to standards appropriate for the specific equipment type, or placing operational restrictions on the equipment, or both.

FRA believes that this approach makes the recommendations more effective and focused.

FRA notes in particular that the reason for including in these recommendations existing equipment that is being placed in service over a new route that the railroad knows to have more demanding track geometry conditions is because the equipment may be subjected to different track conditions (e.g., a route with higher-degree-of-curvature track or a route with track that is maintained to lower standards) and interact differently with the track, potentially leading to similar wheel-climb derailments. In addition, FRA believes that some railroads may not be aware that the equipment they are operating is prone to such derailments because they are already taking some action that mitigates the derailment tendency of the equipment. For example, a railroad may have decided, for unrelated reasons, to maintain the track over which the equipment travels to higher, Class 2 standards, even though the track is formally designated as Class 1. If the railroad were to stop maintaining this track to Class 2 standards without taking any other action to mitigate the risk (e.g., by putting operational restrictions on the equipment), it is possible that the equipment would begin exhibiting similar derailment tendency.

Recognizing that certain newer suspension system designs may result in equalization performance in the AW3 loading condition that makes the equipment more prone to derailment than when it is in the AW0 loading condition, FRA believes it is important to evaluate the equalization of suspension systems in the AW3 loading condition as well. Accordingly, FRA recommends that railroads and other industry members ensure that such evaluation is conducted using the AW3 loading condition for

all new passenger equipment and for the three categories of existing equipment identified in this notice. This will help ensure that the suspension system will be able to prevent wheel unloading when the equipment is loaded to capacity.

Although assessment of wheel-load equalization is important in preventing the wheel unloading and wheel climb indicated in the subject derailments, FRA has determined that the tests and analyses typically used for evaluating wheel-climb and wheel-unloading tendency could be enhanced by including a curving-performance assessment with track-warp variations at the Class 1 limits<sup>5</sup> for a broad spectrum of wavelengths. For example, in reviewing the information available for eight recent low-speed, wheel-climb derailments<sup>6</sup> involving multi-level vehicles,<sup>7</sup> it was discovered that three of the vehicles derailed at or near track warps of a broad spectrum of wavelengths (i.e., a 3-inch track warp in 62 feet, a 1.75-inch track warp in 30 feet, and a 2-inch track warp in 10 feet). Although track geometry data was not recorded for all eight incidents, based on the computer modeling conducted by the equipment manufacturer during the derailment investigations to assess the capabilities of the subject vehicle type, it is likely that the five other vehicles derailed under similar circumstances. Thus, FRA is recommending that all new, and the three categories of existing, passenger equipment identified in this notice be evaluated to determine whether the suspension systems prevent wheel climb while negotiating, at a minimum, a 12-degree curve with a coefficient of friction (COF) representative of dry track conditions (i.e., 0.5) and 3-inch

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<sup>5</sup> See § 213.63, prescribing limits for the difference in crosslevel between any two points (measured along the rails of the track) less than 62 feet apart. For FRA Class 1 track, the difference in crosslevel may not be more than 3 inches.

<sup>6</sup> Nothing in this safety advisory is intended to place responsibility for these incidents on the acts or omissions of any person or entity.

<sup>7</sup> These multi-level vehicles were placed in service between 2006 and 2008, and were designed to provide stable operation at speeds up to 125 mph and meet clearance requirements.



track warp variations with the following wavelengths: 10, 20, 40, and 62 feet. FRA also recommends that, under both the AW0 and AW3 loading conditions, the ratio of lateral force to vertical force (“L/V ratio”) on any wheel not exceed, for a duration of more than 5 feet, the ratio given by Nadal’s limit with a COF of 0.5 (i.e., the FRA single-wheel L/V ratio criterion in § 213.333).

In addition, FRA notes that sensitivity studies conducted by the equipment manufacturer and FRA using computer modeling indicate that an uneven wheel-load distribution has a significant influence on the margin of safety against derailment. That is, passenger equipment with a wheel having a static load up to 10-percent below the nominal load can tolerate significantly less track warp even when the equipment meets the APTA equalization standard. Therefore, FRA is recommending that all new passenger equipment and the three categories of existing passenger equipment identified in this notice be evaluated to determine whether the suspension systems control static wheel-load distribution when the equipment is stationary on perfectly level track such that the lightest wheel load deviates by no more than 5 percent from the nominal wheel load.

Furthermore, while the subject derailments were primarily related to trackworthiness issues, in several other recent low-speed derailments, FRA has determined that broken primary springs were a contributing factor. Although it appears that high coil-to-coil contact stresses within the end coils were a large contributing factor to the broken suspension springs in these derailments, FRA is also aware that spring failures are likely to occur when the fatigue life of suspension springs and their corresponding maintenance intervals are inadequately determined.

Additionally, FRA understands that softer springs, which may be selected to provide better wheel-load equalization (and correspondingly decrease the likelihood of the subject low-speed derailments), may be more prone to failure and consequently may need more frequent maintenance than the stiffer springs. In order to ensure that springs are capable of withstanding both the static and dynamic loads imposed in service under all passenger loading conditions from empty (AW0) to full capacity (AW3), FRA is recommending that the fatigue life of suspension springs and their corresponding maintenance intervals be determined using a fatigue-evaluation load equal to the full-capacity loading conditions. As is the case with the other recommendations in this notice, FRA has limited the applicability of this recommendation, namely by applying it to all new passenger equipment designed with suspension springs, and existing passenger equipment with such springs when the springs are redesigned.

FRA believes that addressing the above interrelated issues through the recommended measures will reduce the risk of wheel-climb derailments over more-demanding track geometry conditions found in low-speed operating environments. In addition, FRA anticipates that implementation of the recommendations through redesign will promote interoperability of passenger equipment throughout the U.S rail network and help avoid the need for equipment-specific track geometry limits or operational restrictions, or both.

**RECOMMENDED ACTION:** In light of the observed passenger equipment design trends and recent incidents, FRA recommends that railroads and other industry members take the following actions:

1. Evaluate the trackworthiness of the following equipment types intended for use in the United States:

- All new passenger equipment types.
- Any existing passenger equipment type that is undergoing a redesign of its suspension system that will likely affect the low-speed trackworthiness performance of the vehicle.
- Any existing passenger equipment type that is being placed in service over a new route that the railroad knows to have more-demanding track geometry conditions (e.g., curvature, warp, etc.).
- Any existing passenger equipment type that has experienced one or more low-speed, wheel-climb derailments that may have had a combination of wheel unloading and track warp of 3 inches or less as a contributing factor.

Such evaluation should take into account the full range of component tolerances and maintenance limits, and determine whether—

- a. Suspension systems meet the APTA truck equalization standard, APTA SS-M-014-06, Standard for Wheel Load Equalization of Passenger Railroad Rolling Stock (2007), under both the AW0 and AW3 loading conditions.
- b. Suspension systems prevent wheel climb while negotiating, at a minimum, a 12-degree curve with a COF representative of dry track conditions (i.e., 0.5) and 3-inch track warp variations with the following wavelengths: 10, 20, 40, and 62 feet. Under both the AW0 and AW3 loading conditions, the L/V ratio on any wheel should not exceed, for a duration of more than 5 feet, the ratio

given by Nadal's limit with a COF of 0.5 (i.e., the FRA single-wheel L/V ratio criterion in § 213.333).

- c. Suspension systems control static wheel-load distribution when the equipment is stationary on perfectly level track such that the lightest wheel load deviates by no more than 5 percent from the nominal wheel load.
2. If the results of the trackworthiness evaluation conducted in accordance with recommendation 1 of this notice indicate that the passenger equipment does not meet one or more of the conditions specified in that recommendation, or if a railroad otherwise has knowledge that the equipment does not meet one or more of these conditions, take appropriate action to address the equipment's derailment tendency as follows:
    - a. For new equipment or equipment undergoing a redesign of its suspension system that will likely affect the low-speed trackworthiness performance of the vehicle, as applicable, redesign the suspension system so that it meets truck-equalization industry standards, prevents wheel climb, and controls static wheel-load distribution under the conditions and within the limits specified in recommendation 1 of this notice.
    - b. For existing equipment that is being placed in service over a new route that the railroad knows to have more-demanding track geometry conditions, or that has experienced one or more low-speed, wheel-climb derailments, as described in this notice, redesign the suspension system as described in recommendation 2a of this notice, or take other appropriate action to mitigate the derailment tendency, such as by ensuring that the track over which the

equipment is operating is maintained to standards appropriate for the specific equipment type, or by placing operational restrictions on the equipment, or both.

3. For all new passenger equipment types designed with suspension springs, and for existing passenger equipment types with such springs when the springs are redesigned, ensure that the fatigue life of the springs and their corresponding maintenance intervals are determined using the AW3 loading condition.

FRA encourages railroads and other industry members to take actions that are consistent with the preceding recommendations and to take other actions to help ensure the safety of the Nation's railroads, their employees, and the general public. FRA may modify this Safety Advisory 2013-02, issue additional safety advisories, or take other appropriate actions it deems necessary to ensure the highest level of safety on the Nation's railroads, including pursuing other corrective measures under its rail safety authority.

Issued in Washington, DC, on March 11, 2013.

Robert C. Lauby  
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for Regulatory and Legislative Operations

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